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Thermomechanical and nonlinear plasmonic modeling of laser-field emission from extended nanostructured cathodes

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Laser-field emission is a process that can produce electron beams with high charge density and high brightness with ultrafast response times. Using an extended nanostructure, such as a nanoblade, permits plasmonic field enhancement up to 80 V/nm with an incident ultrafast laser wavelength of 800 nm. Stronger ionizing fields lead to higher current densities, so understanding how this field is attained will aid in further increasing brightness. In this analysis we study the nanoblade system thermomechanically and plasmonically. The structure is a silicon wedge with a 20-40 nm thick gold coating. We model the constituent materials as temperature-dependent, nonlinear dielectrics. The bulk geometry is well-represented in the finite element framework. We first perform a modal analysis of the surface plasmon polaritons using a 2-D slice of the blade. Next, we perform a 3-D steady-state calculation of the electromagnetic fields, the electron temperature, and the lattice temperature within a frame following the perturbing laser pulse. With these tools we study the peak fields and temperatures achieved as functions of the blade geometry and laser parameters.

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